White paper

DIGITALISATION

Tech strategy process 2020-2021

December 2020

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1. Introduction

1.1 About the white paper

In this white paper, a group of experts from departments across Tech set the scope for a discussion on how the overall ambitions of Tech in the field of digitalisation can be put into practice in the future. The purpose of the white paper is to contribute with infield knowledge and ideas to be used in the process of development of a strategy for the faculty. In it we define a long-term ambition and point out key action areas, where work on digitalisation can start, where it should continue, and from where it can develop ahead. The white paper thus focuses on the efforts at faculty level as it sets a strategic common direction across the departments. Moreover, the paper provides input on strategic opportunities and does not deal with the need for increased funding, resources or new recruitment.

The white paper has been prepared from November to December 2020, where it will be handed in to the deanship and the faculty management of Tech, who will make the decision of implementing initiatives for digitalisation, which aligns with the input from the three other focus groups.

The white paper is developed in an accelerated process where a group consisting of 10 employees from Tech's departments has put forward an idea of how the faculty can work with a strategic effort at digitalisation. Thus, the white paper emerges from a specific context and a specific group of employees with unique competences and professional expertise, and is to be regarded as such. Ambition, initiatives etc. should be adjusted on a continuous basis and will be developed as the cooperation matures. There will be a concrete evaluation before all major initiatives are launched.

2. Focus and status for digitalisation

2.1 Definition and scope of digitalisation

The economy, society and research community are becoming greener and more digital. Branded as a "twin transition", the changes are expected to bring innovation and changes to our everyday lives, moving towards more digital, climate and environment friendly options. The sectors that Tech is dealing with are on the verge of technological quantum leaps providing new tools and potential to solve societal challenges.

Tech is centrally placed to contribute to a successful twin transition because it aggregates a mix of expertise in the green and digital areas with a high number of research projects in the field of digitalisation and green transition. However, while the faculty has clear positions of strength especially in domains related to the green transition, preserving and expanding the leading position in these fields requires strong competences in digital and databased technologies. Digitalisation is key for understanding how to deal with the green transition and to deliver on this transition. Digitalisation is also vital for interdisciplinary research, cooperation across the faculty and the backbone of our infrastructure.

Accordingly, the theme both relates to how Tech should work with digitalisation internally and how Tech can contribute to the digital transformation of society and the solutions for tomorrow that will be based on digital technologies. More specifically this white paper addresses how Tech should work with digitalisation in order to improve research, advisory and teaching and education to ensure that our graduates are ready for the labour market of the future and make sure that Tech has impact on society by providing research-based solutions on green transition and digitalisation. Finally, the white paper also deals with how digitalisation can help facilitate collaboration internally in Tech and with external partners.

2.2 SWOT-analysis

The starting point for the white paper is the SWOT-analysis below, describing the strengths, weaknesses, opportunities and threats for Tech's effort at digitalisation. The SWOT-analysis describes the understanding of the framework conditions that underlies the ambitions, dilemmas and key action areas in the field of digitalisation.

Strengths

In the context of digitalisation, Tech has a range of significant strengths. There is massive demand for our graduates, strong educational programmes and staff as well as a strong brand in certain areas and competent advisory for authorities. Tech has a history of successful grant applications and publications as well as cooperation on courses among faculty members. The faculty has close cooperation with businesses and industry and the staff and researchers at Tech have diverse backgrounds combining industrial and academic experience.

Tech is strong in applied research and research based public sector consultancy, and the departments of the faculty cover all "green" areas being the leading faculty in many of these also with the use of data and digital technologies. Tech also covers "digitalisation" with expertise of the Electrical and Computer Engineering Department and its leading role in DIGIT, one of Aarhus University's thematic centres. This centre focuses on digitalisation, big data and data Analytics, which enables internal collaboration and synergies with other departments and thematic centres (e.g. iFOOD and WATEC) as well as synergies with groups with strong competences in modelling of complex inside the faculty.

Tech has access to unique data and is the owner of central databases in fields related to green transition such as environmental and nature data, climate data, agriculture, animals, food etc. In other words, Tech is carrying out research and handling data across the whole value chain from farm to fork and the environmental impacts and beyond. There are innovative data collection methods/tools and predictive models in the departments. The faculty is particularly strong in data from sensor platforms (IoT) and has experience in utilisation of complex and unstructured data from robots and sensors. Tech is also leading in public sector advisory/consultancy with its quality Management system for research-based public sector consultancy, which is certified according to ISO 9001. Through the advisory and consultancy for public authorities, Tech has in-depth knowledge of the societal challenges.

Finally, as demonstrated under the current pandemic, Tech and AU have good digital education platforms that can be developed further by tailoring courses even better to the online context.

Weaknesses

The focus group identified several key weaknesses in the faculty's work with digitalisation.

A large group of the identified weaknesses are related to the lack of data sharing, data reuse and access across Tech/AU and with external partners (NGO's, public- and private actors). The infrastructure and management around data, which often is characterised by organisational and project-based silos makes it difficult to address the challenges of the future. It is a challenge to combine data and to work with common data collection, which may result in poor metadata and even loss of synergy resources and data. The lack of overview of data in Tech hinders interdisciplinary innovation. It seems difficult to upscale a data management system due to lack of competences. Expertise and competences in the application of big data, AI and Machine Learning need to be mainstreamed across the faculty.

Related to this, the focus group highlighted weaknesses on infrastructure and available computing capabilities. There is limited infrastructure (servers, computing power, lab and experimental

equipment) and the internal it-systems can be burdensome. There is a lack of a hybrid solution between the locally distributed and Tech managed it-services.

A group of weaknesses relates to the lack of cooperation and coordination both in general and in the field of digitalisation across the departments in Tech and with the Faculty of Natural Sciences. There seems to be weak economic and professional incentives to working across faculty and a lack of overview of digital aspects and competences in Tech that lead to lack of interdisciplinary collaboration and replicability. This also relates to the fact that Tech is a young faculty, which does not yet have clear profile and identity in the digital field. In addition, the knowledge of activities and competence in Tech is not well distributed in the faculty.

Finally, the group emphasized that the faculty should know its most important "customers" better (businesses, authorities, research institutions and NGO's).

Opportunities

Tech is centrally placed to contribute to a successful twin transition by delivering the digital and green solutions for the societal challenges. The sectors that Tech are dealing with are on the verge of technological quantum leaps providing new tools and potentials to solve societal challenges.

Tech meets a massive demand from the political level, society, industry and consumers for solutions to societal challenges and funding opportunities in Tech's research is increasing. The faculty has clear positions of strength especially in domains related to the green transition. TECH can provide solutions within the field of collecting environmental and nature data on the demand from e.g. authorities on high time and spatial resolution, up to date and cost effective data collection and compilation. Preserving and expanding the leading position in these fields requires strong competences in digital and databased technologies. It implies that Tech excels in re-using, sharing, combining and exploiting data across the faculty, the university and with external partners.

The establishment of a shared infrastructure and management for data and computing (e.g., in the form of better coordination around common data solutions) can power interdisciplinary research and synergy e.g., in the field of green transition, feed into education of students and PhD-programmes as well as feed into our cooperation with industry and advisory for ministries. This is also expected to improve Tech's ability to participate in large scale EU-applications.

With the diverse range of capacities at Tech, the faculty can work with research and development at all technology readiness levels. Efforts can be targeted on research directly applicable to industrial collaborators and fundamental research, where Tech can become a leader with continuous contributions through time.

The focus group identified a range of opportunities centring on increased collaboration internally in the faculty and with external partners. Core collaboration between different competence areas can increase the level and speed of innovation i.e. by better use of methods across application areas. There are opportunities bringing competences together from across the faculty on new larger projects. The group highlighted that cooperation between engineers and other fields (e.g., Agro, ANIS, BIOS, ENVS, QGG) can create a distinct Tech-profile that is attractive to external partners.

Threats

Finally, the focus group highlighted a number of threats that may materialize down the road. Ultimately the risk is that the otherwise great demand for services related to societal challenges cannot be met and utilised by TECH due to inconsistent data management and insufficient computing capacities and because Tech is not utilizing the opportunities in data processing and modelling across the faculty. Other universities will be preferred in international calls and public advisory if we do not improve significantly and urgently on uniform data management and creative modelling and use of collected data. Moreover, we need to provide better support for establishing and leading large consortia in terms of both technical infrastructure, scientific leadership and management support.

Another related threat is if Tech does not succeed in combining the digital and domain expertise, it will create an increasing gap in understanding between researchers in sector/field and researcher in AI or machine learning.

These might be the consequences if the current approach with departments wanting to do everything "on their own" due to felt ownership of problem and data continues. Too slow establishment of new digital profile and identity for Tech and a limping employment of databased technologies and computing power will increase the risk of such negative outcome. It can also be an unintended consequence if the work with data infrastructure and management ends up with the establishment of parallel infrastructures that do not fit with international standards.

Worries about clarifying and delivering on open science as well as lack of contacts in both the private- and public sector were mentioned as elements that negatively affect collaboration with external partners.

The focus group also pointed to a number of more general but related threats such vulnerability due to a high degree of external funding, not enough staff for teaching and developing new courses and the competition for talent. It was also pointed out that prioritizing which societal challenges to address is challenging and that top down push of strategies to do research within certain areas can have a demotivating effect.

3. Ambition for digitalisation

3.1 Strategic ambition and indicators

Based on the analysis of strengths, weaknesses, opportunities and threats, the focus group has formulated the following overall ambition, which should guide the strategic direction of Tech's work with digitalisation:

> *Tech is the leading faculty in research, advisory and education in computer and data intensive solutions for green transition and other societal challenges for and with society.*

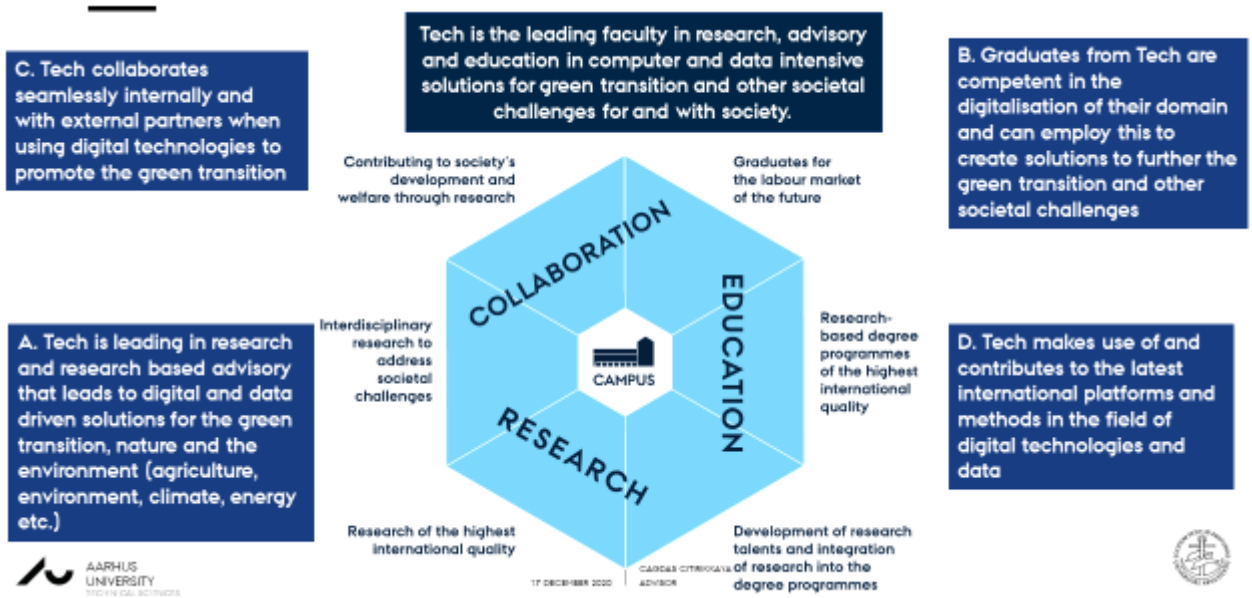
In order to become the leading faculty in research and education in digital and data driven solutions in the field of green transition, Tech needs to succeed with the following four key indicators (strategic sub-goals) that feed into the overall ambition:

A. Tech is leading in research and research based advisory that leads to digital and data driven solutions for green transition, nature and the environment (agriculture, environment, climate, energy etc.)
B. Graduates from Tech are competent in the digitalisation of their domain and can employ this to create solutions to further the green transition and other societal challenges

C. Tech collaborates seamlessly internally and with external partners when using digital technologies to promote the green transition
D. Tech makes use of and contributes to the latest international platforms and methods in the field of digital technologies and data

Relation to AU-strategy

The ambition and the four key indicators complement the AU strategy 2025 by feeding into the relevant core tasks at AU level as illustrated here:



3.2 Key dilemmas

Working with these ambitions in the field of digitalisation relates to certain key dilemmas between opposing legitimate concerns. To deliver on our ambition Tech needs to strike the right balance in these dilemmas. The following are the key dilemmas identified by the focus group and suggestions on how to address them:

<u>Decentralised data infrastructure and management VS Central/shared data infrastructure and management</u>

The SWOT-analysis and the ambitions clearly point towards the need to work with the data infrastructure and data management in order to meet requirements in these areas and reap the benefits of research and teaching powered by data. The group finds that the current decentralised data infrastructure and management has clear vulnerabilities and limits data utilisation, sharing and re-use across the faculty and the university. Therefore, work must be undertaken to move towards more central or shared data infrastructure and management. However, these efforts should consider individual needs and not be understood as implementing one central system as such. Making the logical and applied data models should be done with very strong involvement and leadership by employees that know the field-specific formats and conventions as well as how data are collected and can be scientifically used.

Flexible local it and central it system and computing power

In order to attract and provide better it-capacities and support for larger projects, Tech needs to improve its it-structure and computing power. These efforts should not replace existing solutions to local projects where shared computing power or it-systems are irrelevant.

Domain expertise VS Expertise in digital technologies / Computer engineering vs Application of engineering

Tech covers both expertise in digital technologies as such and expertise in various domains (agriculture, food, environment etc.). Rather than focusing our efforts in one direction, it is central for the formulated ambitions that Tech should strive to combine the domain expertise with the expertise in digital technologies and digital engineering. More specifically, the faculty should reap opportunities for increased collaboration between capacities in computer engineering, modelling and the different domains especially in order to increase application in areas related to the green transition.

Open data VS Data lock-in and protection

Tech is increasingly met with demands to provide access to more data and data services and to do so in a more efficient and seamless fashion. By delivering on this, the data can be utilised by other researchers, students and external actors for innovations, products and services. On the other hand, there are strong incentives to limit access to data and research in order to protect the researchers' innovations at least until the research projects have concluded. Moreover, there can be justifiable reasons to protect data according to data agreements with external partners and regulation (e.g. the GDPR). The group recommends that Tech should strive for more and better access to data taking the necessary precautions for ongoing research.

Digital education/online campus VS Physical presence/campus 2.0

As a result of the current pandemic, the university and the faculty have progressed significantly in the field of digital education. This field can be further developed and be inspired by the engineering department that currently has a fully online bachelor programme. However, this will have to be balanced against the positive sides to physical presence both related to social aspects, physical facilities and equipment, synergies following geographical proximity and the vision behind Campus 2.0.

The group has also discussed the dilemma whether the focus on societal challenges should be narrowed to green transition only or rather some of the UN Sustainable Development Goals in general also including health, poverty, equality etc. The group preferred to refer to green transition covering environmental protection, biodiversity, life below water and on land and fighting climate change as a strategic focus as Tech has unique standing and potentials in these areas while this focus does not in any way rule out work related to other UN Sustainable Development Goals.

4. Possible key action areas

The focus group suggests that action on a number of key areas is necessary to deliver on the ambition. The key action areas have been prioritised in the following three clusters by the group based on their urgency and expected effect.

4.1 Start here (most urgent and largest effect)

1. Becoming frontrunners in data and computing infrastructure and management

The SWOT-analysis and the ambitions clearly point towards the need to work with the data infrastructure and data management in other to meet national and international requirements in these areas and reap the benefits of research and teaching powered by data from across the faculty. Great demand for services related to societal challenges and international calls in the field cannot be met due to lack of uniform data management and inaccessible data. Tech should capitalise on its positions of strength in data processing and modelling through increased collaboration across the faculty.

By working towards a shared data and computing infrastructure and management across the faculty's facilities and research areas, Tech can utilise its positions of strength being the owner of central "green" databases and having access to data e.g. from sensor platforms and valuable experience in validation and utilisation of complex and unstructured data from robots and sensors. This work should clarify which aspects should be shared and which should be handled on department-level so the work does not lead to a "mass grave of data".

Data utilisation across Tech and the university as whole can power interdisciplinary research and synergy e.g. in the field of green transition and bring about fundamental green research breakthroughs and green digital technology transition and bring our cooperation with external partners such as industry and advisory for authorities to the next level.

To ensure data utilisation across the faculty and AU, Tech needs to progress significantly in the following four areas:

- Shared data infrastructure/capacity and computing power e.g., by the establishment of a common data management platform and a cloud computing center
- Shared data management allowing for greater access, combination and re-use of data, diffusion of innovative data collection methods/tools and predictive models and countering data loss and poor metadata
- Work across faculty to improve competences in how to apply AI, big data analysis and Machine Learning, inference and predictive analysis to areas of green transition
- Expand position of strength in data acquisition and sensor development (IoT)

2. Cooperation and interdisciplinary research across Tech powered by digital technologies and data

As demonstrated by the SWOT-analysis, Tech must improve its cooperation across its departments and improve interdisciplinary research in order to provide the green solutions of tomorrow, which will be based on digital technologies. Tech must move beyond the idea that "all departments want to do everything on their own" and rather facilitate radical collaboration internally and with external partners to increase the level and speed of innovation. Tech needs to be the faculty that excels in combining digital and domain expertise to find solutions on the green transition. The focus group is convinced that increased cooperation internally in the faculty and especially between engineers and other fields can create a distinct Tech-profile as the departments in the faculty cover all green areas and are leading in many of these.

Specific strands of action could be providing clear overview of data and digital capacities/competences across Tech, clearly defining the societal challenges that will structure interdisciplinary focus, better

use of methods across application areas, establishing a knowledge sharing platform (for both internal and external use). The abovementioned data infrastructure is necessary to succeed with data utilisation across Tech/AU and with public and private sector, which will bring cooperation to the next level.

3. Boosting the digital competences of our graduates

A key action area is to ensure that graduates across all disciplines in Tech understand as a minimum how digital technologies and methods of analysis such as big data, machine learning, AI, predictive modelling and IoT can be employed in their field. This will both ensure that they are graduates for the labour market of the future and improve their tools to create solutions to further the green transition and other societal challenges.

Specific strands of action could include incorporating activities in existing courses or increased cooperation between the departments and the forthcoming Department of Electrical and Computer Engineering as well as the Department of Computer Science and the Department of Mathematics and other groups in Tech that focus on modelling and big data analysis.

4. Tech's digital profile/brand

Tech needs to establish a clear profile/brand in the digital field that can be easily communicated internally and externally. This profile must build upon the unique positions of strength that the faculty has in bridging digital expertise with domain expertise in the green fields.

4.2 Make sure to progress here (urgent and significant effect)

5. Larger flagship projects on green and digital transition

Powered by the action areas above on collaboration and common/shared data infrastructure and computing power, Tech should launch and attract larger flagship projects that bring the faculty's departments to deliver research breakthrough in the nexus between digital and green transition.

6. Cooperation with external partners

In order to ensure that Tech's research and innovations have impact on the society and contributes to solving the societal challenges, Tech should engage in projects and partnerships with external partners to develop, test and diffuse digital innovation and solutions in fields related to the green transition. Following the key action areas above, this cooperation should to a higher extent be powered by data.

7. Digital and online education

Tech should build upon the current momentum in digital education to develop long term solutions that take full advantage of the possibilities in digital education.

4.3 Don't forget to consider these areas (important but less urgent)

- Using digital tools to apply and develop Tech's certified quality management system.
- Digital Entrepreneurship and commercialisation: Promoting entrepreneurship among Tech's students, researchers and graduates.
- Attracting digital talent should be an integral part of the faculty's general work to promote recruitment and talent.

4.4 Attention points for realising the ambition

The focus group has identified the following special focus areas/attention points related to delivering on the ambition with the key action areas. The attention points can be seen as opportunities if addressed properly.

- Digitalisation requires close cooperation with the Faculty of Natural Sciences and in particular the Department of Computer Science and the Department of Mathematics that are parts of the DIGIT Centre.
- Following international developments in the digital field and the fact that many of our domains are facing a technological quantum leap, there is an urgency related to efforts in the digital field and establishing a strong identity/brand.
- Tech needs to be prepared to share knowledge, results and data with society considering that data sharing within Tech, with businesses and internationally and upholding IPR are challenging.
- There is less tradition for inter-institute collaboration and lack of interdisciplinary and replicability where collaboration around digitalisation can play a key enabling role.
- There is a need for an overview of data and digital capacities in Tech to address the lack of awareness of possibilities in the digital field.
- Address how work with digitalisation across the faculty that does not necessarily end up with a scientific review paper can be merited and credited.
- Limited infrastructure related to both data, hardware, computing power and support coupled with the exponential growth in data represent vulnerabilities that need to be addressed without creating an administrative monster or a “mass grave of data”.

5. Process plan for work with digitalisation

Following the discussion by faculty leadership at the strategy seminar and as an input to the transformation of the white paper into one or more operational plans and strategy process of each department. The focus group recommends that the following next steps be taken in the fields, a) organization of research and research based advisory b) education and teaching and c) technical infrastructure.

<u>a) Organisation of research and research based advisory</u>

1. Mapping specific needs
2. Plan for increased cooperation and interdisciplinary research across faculty including
    - dispersing knowledge on what is happening on department-level through digital means
    - extra support for cross-cutting projects
    - Creating a forum for interdepartmental discussion and project development
3. Formulate and launch Tech’s digital brand

<u>b) Education and teaching</u>

1. Mapping specific needs
2. Work on ensuring minimum digital competences for graduates.
3. Developing holistic digital education platform (not only software)

<u>c) Technical infrastructure</u>

1. Initiate work on shared data and it-management/infrastructure
2. Initiate work on data utilization across Tech and with the private and public sectors

6. Composition of the focus group

Chairperson: Brian Vinter (vice-dean for research, Tech)
Facilitator: Cagdas Citirikkaya (advisor, Dean's Secretariat, Tech)
Secretary: Ida Grarup Nielsen (student assistant, Dean's Secretariat, Tech)

Focus group members:

1. Mogens Humlekrog Greve (Department of Department of Agroecology)
2. Søren Østergaard (Department of Animal Science)
3. Hugo Daniel Macedo / Peter Gorm Larsen (Department of Engineering /DIGIT)
4. Peter Langen (Department of Environmental Sciences)
5. Just Jensen (Center for Quantitative Genetics and Genomics)
6. Mikael Bergholz Knudsen (Aarhus University School of Engineering)
7. Lars Moeslund Svendsen (Danish Centre for Environment and Energy)
8. Claus Bo Andreasen (Danish Centre for Food and Agriculture)
9. Kim Kusk Mortensen (Nat-Tech Administrative Centre)